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by

P.R.A. Andrews* and W. Kelly**

ABSTRACT

A preliminary evaluation of a wollastonite sample from Nova Scotia indicated that wollastonite can be concentrated by a combination of magnetic separation and flotation. Magnetic separation reduces iron oxide levels to 0.22% Fe_2O_3 in the -600 +300 µm fraction and to 0.28% Fe_2O_3 in the -300 +150 µm fraction. Subsequent reverse flotation of calcite on material ground to -300 µm removed approximately 85% of the calcite, resulting in a concentrated wollastonite product.

Brightness values of concentrated wollastonite are between 68% and 71%.

Keywords: Nova Scotia, wollastonite, calcite, magnetic separation, flotation.

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ÉVALUATION PRÉLIMINAIRE DE WOLLASTONITE DE LA RÉGION DE MARBLE MOUNTAIN EN NOUVELLE-ÉCOSSE

par

P.R.A. Andrews* et W. Kelly**

RÉSUMÉ

Les résultats de l'évaluation préliminaire d'un échantillon de wollastonite provenant de la Nouvelle-Écosse ont indiqué que la wollastonite peut être concentrée en combinant les procédés de séparation magnétique et de flottation. La séparation magnétique réduit les niveaux d'oxyde de fer à 0,22 % Fe_2O_3 avec les fractions de -600 à +300 µm et à 0,28 % Fe_2O_3 avec les fractions de -300 à +150 µm. L'emploi subséquent de la flottation inverse de la calcite avec un matériau broyé à -300 µm a enlevé environ 85 % de la calcite, et a eu pour résultat la production de wollastonite concentrée.

Les valeurs de luminance de la wollastonite concentrée se situent entre 68 % et 71 %.

Mots-clés: Nouvelle-Écosse, wollastonite, calcite, séparation magnétique, flottation

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INTRODUCTION

In September 1986, a sample of wollastonite from the Marble Mountain area, Nova Scotia, was submitted for evaluation by J. Fowler of the Nova Scotia Department of Mines and Energy.

MINERALOGY

A sample of wollastonite weighing ≈ 4 kg and consisting of fragments up to 75 mm in size was received in the Non-Metallic Minerals Section laboratory. Generally, the fragments consisted of fine to medium grain, clear to grey calcitic marble interlaced with white to buff nemotoblastic subhedral acicular aggregates of banded wollastonite, up to 1.5 cm in thickness. Wollastonite also occurs in blebs up to 3.0 cm in size. Numerous inclusions of fine pale green grains of pyroxene (possibly diopside) up to 1 mm in size, accounting for ≈ 2% of the sample, are disseminated in both wollastonite and calcite. Occasional minor quartz is found as interstitial grains in the marble.

A trace amount of pyritic material as very fine grains is visible in some of the wollastonite assemblages. It appears that pyritic sulphides are concentrated with small dark blebs or veinlets, up to 1.5 cm in size of prinhite as determined by X-ray diffraction.

PROCESSING

SAMPLE PREPARATION

The sample was reduced by a combination of jaw and roll crushing to -4.8 mm. Final size reduction by roll crushing not only minimized the production of unwanted fines but also preserved the relatively high aspect ratio of coarse grained wollastonite.

A representative portion of the crushed sample was sized down to 150 µm, and each size fraction examined microscopically to determine liberation size. The results are reported in Table 1.

Dry beneficiation was conducted on material sized at -600 +300 µm (-28 +50 mesh) and -300 +150 µm (-50 +100 mesh) using the Denver air table,

Alpine zig-zag classifier, the Eriez perm-roll magnetic separator and the Carpco electrostatic high-tension separator. The results of the magnetic separation test are presented in Table 2.

Wet beneficiation by flotation was conducted on material ground to -300 µm and five tests were conducted. The procedure was to float calcite at pH 7.0 using sodium oleate as collector. The pH was then decreased to 4.0 and iron oxide flotation conducted using Aerofloat 840, a natural petroleum sulphonate collector. In Test 4 the iron oxide collector was changed to Duomeen TDO (tallow diamino propane dioleate) at pH 2.0; in Test 5, iron oxide flotation was investigated using Armac T (tallow amine acetate) at pH 2.0. In Tests 3, 4 and 5 sodium silicate was added to aid slime dispersion and quartz depression. Product balances are reported in Table 3 and flotation parameter and reagent concentration data in Table 4.

Brightness values of calcite and wollastonite were measured using a Photovolt Model 577 reflection meter. Aspect ratios also were estimated.

RESULTS

Optical examination of sized fractions showed there was no visible concentration of wollastonite in any size fraction. Neither air tabling nor zig-zag air classification was able to concentrate wollastonite in the -600 +300 µm fraction or the -300 +150 µm fraction.

Magnetic separation successfully removed magnetic silicates and sulphides in each size fraction. A preliminary qualitative test indicated that the iron oxide level could be reduced to 0.22% Fe_2O_3 in the -600 +300 µm fraction and to 0.28% Fe_2O_3 in the -300 +150 µm fraction. Electrostatic separation of the non-magnetic fraction produced a separation of wollastonite from calcite although, only a minor concentration of wollastonite (in the pinned - tailings product) resulted.

Successful separation of calcite from wollastonite was achieved by flotation. With the exception of Test 4, 82 to 88% of the calcite was removed at pH 7.0 using sodium oleate collector. Subsequent iron oxide removal using petroleum sulphonate collector was less successful, since the iron oxide level could not be reduced below 0.85% Fe_2O_3. Other collectors, e.g., Armac T and Duomeen TDO, were equally unsuccessful.

Iron oxide minerals can be removed using petroleum sulphonate collectors, but due to the limited weight of feed material only a few tests were possible and parameters therefore could not be optimised.

Brightness values of the calcite consistently measured ≈ 59%. The brightness values of the concentrated wollastonite varied between 55 to 60% for Tests 1, 2 and 3. The brightness values for Tests 4 and 5 concentrated products were higher, varying between 68 and 71%. The increased brightness values of Tests 4 and 5 is not due to reduced iron oxide levels, which remain high at 0.93 to 0.96% Fe_2O_3. A possible explanation is the absence of the discolouring effect of the petroleum sulphonate residue from the collector Aerofloat 840. This collector was used only in Tests 1, 2 and 3 and concentrated wollastonite products from these tests have relatively low brightness values.

Aspect ratios of concentrated wollastonite were estimated at between 10:1 and 12:1.

RECOMMENDATIONS

The wollastonite content of material used in ceramics and as a filler or extender material in paints and plastics, should be at least 90% $CaSiO_3$; iron oxide content should be low, preferably less than 0.2% Fe_2O_3. Initial indications are that these values could be obtained but, further work would need to be conducted on a larger representative sample.

CONCLUSIONS

Employing a combination of magnetic separation to remove iron oxide minerals and flotation to remove calcite, wollastonite can be successfully beneficiated.

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Table 1. Size analysis and mineral characteristics of the head.

Size	Wt %	Description
-4.8 +2.4 mm	36.0	Wollastonite has maintained a high aspect ratio and is = 70% liberated from calcite. Prinhite is liberated but inclusions of diopside remain unliberated from aggregates of wollastonite. Wollastonite is = 15 to 20% of the fraction.
-2.4 +1.2 mm	21.2	Wollastonite is = 80% liberated from calcite. Diopside still unliberated; minor unidentified dark minerals present. Wollastonite is = 20% of the fraction.
-1200 +600 µm	11.2	Similar to -2.4 +1.2 mm fraction but wollastonite is now completely liberated from calcite; the diopside inclusions are showing liberation. Wollastonite is = 20% of the fraction.
-600 +300 µm	9.5	Liberation is achieved and the wollastonite has maintained a good aspect ratio. Minor unidentified dark minerals present. Wollastonite is = 20 to 25% of the fraction.
-300 +150 µm	9.8	Complete liberation but the aspect ratio of wollastonite is starting to diminish, though it is still high. Wollastonite is = 20 to 25% of the fraction.
-150 µm	11.9	High quantity of calcitic fines, aspect ratio of wollastonite lower than for -300 +150 µm fraction. Wollastonite is = 25% of the fraction.

Table 2. Qualitative magnetic separation tests

Size fraction	Products	Analyses % Fe_2O_3
-600 +300 µm	Magnetics	2.89
	Non-magnetics	0.22
-300 +150 µm	Magnetics	4.61
	Non-magnetics	0.28

Table 3. Product balances

Test	Products	Wt %	Analysis %		Distribution	
			$CaCO_3$	Fe_2O_3	$CaCO_3$	Fe_2O_3
1	1st calcite float	31.9	95.8	0.37	54.3	16.6
	2nd calcite float	24.8	75.2	0.72	33.2	26.8
	1st iron oxide float	5.0	39.0	1.55	3.5	10.9
	Rougher tails	38.3	13.2	0.85	7.0	45.7
	Head (calculated)	100.0	56.22	0.71	100.0	100.0
2	1st calcite float	58.8	84.8	0.63	88.1	47.8
	1st iron oxide float	0.9	39.0	1.81	0.6	2.1
	Rougher tails	40.3	15.8	0.96	11.3	50.1
	Head (calculated)	100.0	56.58	0.77	100.0	100.0
3	1st calcite float	53.9	88.6	0.45	86.6	32.9
	1st iron oxide float	0.8	39.0	1.75	0.6	1.9
	Rougher tails	45.3	15.6	1.06	12.8	65.2
	Head (calculated)	100.0	55.13	0.74	100.0	100.0
4	1st calcite float	51.2	89.2	0.43	74.1	32.4
	1st iron oxide float	2.3	48.0	1.11	1.8	3.8
	Rougher tails	46.5	32.0	0.93	24.1	63.8
	Head (calculated)	100.0	61.65	0.68	100.0	100.0
5	1st calcite float	57.0	85.4	0.47	82.1	39.2
	1st iron oxide float	0.9	53.4	1.17	0.8	1.6
	Rougher tails	42.1	24.0	0.96	17.1	59.2
	Head (calculated)	100.0	59.26	0.68	100.0	100.0

Table 4. Flotation parameter data and reagent concentrations

Test no.	Flotation stage	No. of stage	Cond. time min.	Float time min.	pH	Pulp density % s	Impeller speed r.p.m.	Collectors				Frother	Modifiers	
								Sodium oleate g/t	Aero 840 g/t	Duo TDO g/t	Armac T g/t	M.I.B.C. g/t	H_2SO_4 g/t	Na_2SiO_3 g/t
1	Rougher	3	15	7.5	7.00	20	1300	277.2	231.0	-	-	133.1	1972.3	-
2	Rougher	2	10	5.0	7.02 & 4.00	20	1300	462.9	462.9	-	"	133.3	5348.6	-
3	Rougher	2	11	4.5	7.02 & 4.00	20	1300	372.1	232.6	-	-	134.0	4895.3	930.2
4	Rougher	2	10	5.0	7.00 & 2.00	20	1300	358.6	-	224.1	-	96.8	25293.4	896.5
5	Rougher	3	10	4.0	7.00 & 2.00	20	1300	378.7	-	-	236.7	68.2	21323.2	946.8